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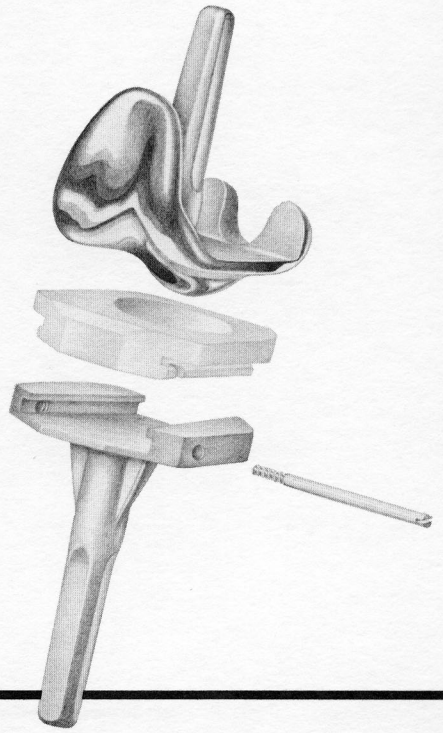
Surgical Techniques

Variable Axis™ Total Knee Surgical Technique

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Variable Axis™ Knee Prosthesis Surgical Technique

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The Variable Axis™ Knee Prosthesis was devised to attempt to minimize the occurrence of loosening of components at the bone-cement interface. The criteria utilized to develop the design were the following:

A. Absolute criteria
1. Metal-polyethylene articulating surfaces
2. Metal-methacrylate-bone fixation
3. Capability for motion about three axes — transverse, AP, and longitudinal

B. Desirable criteria
1. Bone resection compatible with subsequent arthrodesis
2. Small inventory requirement
3. Simplified insertion
4. Broad contact areas for fixation
5. Stems for secure seating

The resultant prosthesis is a semi-restrained prosthesis, depending upon a central ball-and-socket articulation between the femur and tibia and lateral extensions of the femoral prosthesis to provide stability in valgus-varus directions. The central ball-and-socket articulation allows for rotation about a longitudinal axis of 365 degrees so that rotational torque at the bone-cement interface is minimized during weight bearing. The central major articulation also reduces stress across the joint by concentrating it over the stems where fixation is greatest.

The indications for the use of this prosthesis include the following:
1. Destructive changes of the knee joint secondary to rheumatoid arthritis.
2. Degenerative arthritis involving both compartments.
3. Failed previous arthroplasty.
4. Post-traumatic arthritis with deformity of the articular surfaces.

Contraindications include:
1. Previous sepsis.
2. Neuropathic joint disease.
3. Pre-existing surgical arthrodesis of the knee.
4. Flexion contracture of 60 degrees or greater.
5. Valgus or varus malalignment greater than 30 degrees non weight bearing.

Description of Prosthesis

The prosthesis consists of four separate parts.

Femoral Component:

The femoral component is contoured to fit the distal end of the femur with a patellar flange extending anteriorly and proximally. The characteristic feature is a central sphere which has a radius such that the center for rotation of the knee in flexion-extension is located near the anatomic center of the knee joint. Rotation about a longitudinal axis can occur throughout the range of flexion-extension on the femoral component so that the "instant axis" varies from moment to moment during motion. The central sphere has a groove running onto it from the patellar surface so that the patella can glide onto the sphere without serious impingement. The posterior portion of the sphere has been flattened and notched to allow access to the posterior com-

partment of the knee joint for glue removal and to prevent pressure on posterior capsular structures in full extension.

Tibial Plateau Holder:

The major tibial component is a metal tray with a stem for intramedullary fixation. The tray is constructed to hold the polyethylene articular insert and is beveled from front to back to allow positive seating of the polyethylene. The intramedullary stem is slightly anterior on the tray to facilitate insertion.

Polyethylene Articular Insert:

The tibial articular surface is a polyethylene insert which has a central socket to articulate with the sphere on the femoral component. The remaining portion of the tibial insert is flat so that rotation can occur unrestricted in any direction. A hole is present in the base of the socket to allow accumulation of debris and minimize wear. The polyethylene insert comes in five sizes — a standard or universal thickness, a slightly thicker insert, an extra thick insert, and a set of beveled articular surfaces elevated on the right or the left side to allow correction of valgus or varus malalignment. Tibial inserts are interchangeable so that accommodations can be made after the femoral and tibial components have been firmly cemented, to improve stability and/or alignment.

Locking Pin:

A locking pin threaded on one end and inserted from left to right through the tibial plateau holder is used at the completion of the procedure to lock the tibial insert in place.

Necessary Instruments

Several special instruments are helpful in the performance of the arthroplasty.

Spacing Block:

A spacing block shaped like the tibial plateau surface and equaling the assembled prosthesis in thickness is used to determine the amount of bone to be resected and to assist in correcting alignment and insuring proper prosthetic fit. A central slot is present to allow the use of a marker for the prosthetic stems and two holes are present on either side of this notch for insertion of an instrument to adjust the spacing block.

Stem Locator:

An instrument with a spike for marking the bone can be utilized to assist with locating the appropriate position for the prosthetic stems. After placing the spacing block in the interval between the femur and tibia, the marker is inserted into the central slot and tapped against the femoral and tibial surfaces alternately to leave a mark.

Femoral Shaping Jig:

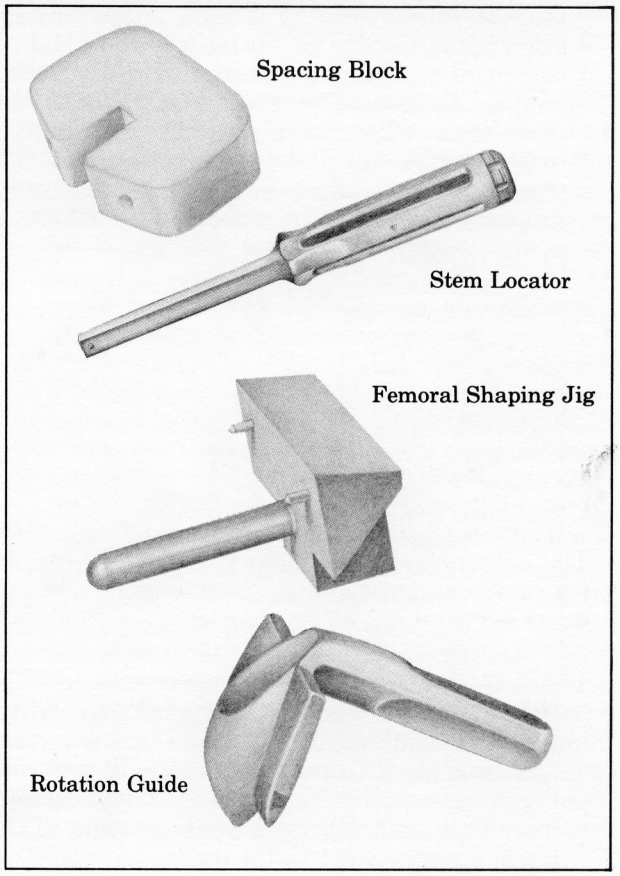
A jig with several angled and flat surfaces is utilized to determine the appropriate shape for the distal end of the femur. A central stem fits into the stem hole made for the prosthesis in the femur and cuts are made in the end of the femur parallel with the surfaces of the jig.

Rotation Guide:

In order to determine the appropriate alignment of the femoral prosthesis about the longitudinal axis of the femur, a guide is fashioned with a central sphere similar to the undersurface of the femoral prosthesis. This is seated on the femur after placing the tibial plateau holder and polyethylene insert in the tibia and the knee is articulated and flexed to insure that the guide articulates smoothly with the tibia. The location of the anterior surfaces of the guide are marked on the femur to provide an index for placement of the femoral shaping jig.

Other Instruments

Other instruments required for the procedure are standard osteotomes, bone saws, rongeurs, etc. A standard femoral prosthesis driver is used in seating both femoral and tibial components.



Detailed Directions for Variable Axis™ Knee Prosthesis Insertion

1. Standard skin preparation, draping, exsanguination, and tourniquet techniques are employed. The position of the patient on the operating table is supine, modified by a roll under the ipsilateral hip if the leg tends to stay in an externally rotated position.
2. A medial parapatellar incision is made with displacement of the patella laterally. This may require partial release of the patellar tendon insertion along the medial side.
3. The knee is flexed and the anterior joint debrided including menisci if present. Capsular attachments to proximal tibia are separated to allow visualization of the margins of the tibial plateaus. Soft tissue is removed from the anterior surface of the femur for a short distance above the patellar articular surface to allow positive identification of the anterior femoral cortex.
4. Initial Cut: Less than 0.5 cm. is removed from the proximal tibia with a reciprocating saw in a plane perpendicular to the long axis of the tibia. (Figure 1) The fragment of tibial plateau is removed by cutting posterior capsular attachments as it is pulled forward. It is essential to remove minimal tibial plateau surface to insure eventual stability of the prosthesis. When one plateau is significantly depressed beyond the anticipated line of cut, the cut is made as above, leaving the depressed area to be filled in with cement. When an

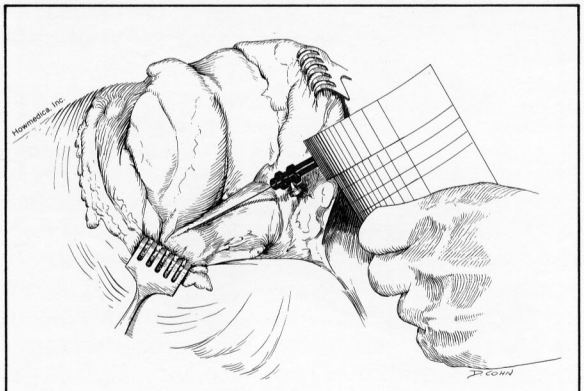


Figure 1

entire plateau is sharply angled downward, the initial cut should be made in a way that will provide a flat surface extending across the proximal tibial to a point just beyond midline. This will allow adequate seating of the tibial component.

5. Second Cut: The knee is then extended fully and there should be up to 0.5 cm. of space between the cut tibial surface and the distal end of the femur. Longitudinal traction is placed on the leg with the knee in a fully extended position and visually aligned to avoid excessive varus or valgus. The distal end of the femur is then marked 20 mm. proximal to the cut upper edge of the tibia. This may be done by measuring or by using the spacing block as a guide. A transverse cut is made across the distal femur at this level, parallel to the proximal cut surface of the tibia with the knee in full extension. It is safe to saw halfway through toward the posterior aspect with the knee in extension following which the knee should be flexed to complete the cut through the posterior femoral condyles to avoid jeopardizing posterior popliteal structures (Figure 2).

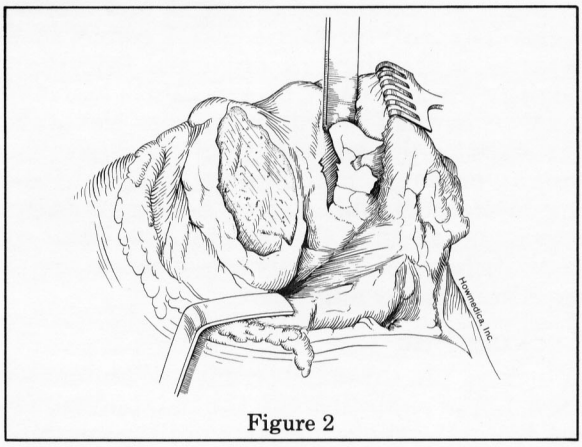


Figure 2

6. At this point, there should be an even space of 20 mm. between the cut ends of the femur and tibia with the knee in full extension. The spacing block can be inserted and with the block in place, the knee should be stable (Figure 3). If the spacing block cannot be inserted, additional bone must be removed from the femur until the block fits snugly.

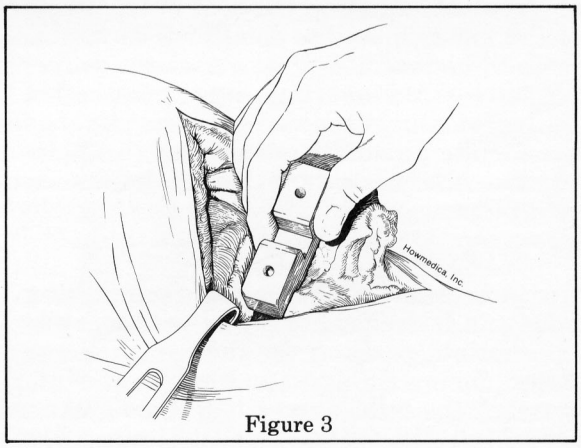


Figure 3

7. The spacing block is fit between the femur and tibia and placed so that the anterior edge of the block corresponds to the anterior edge of the tibia and the slot faces directly anterior. With the knee in extension, the marking guide for the stems is inserted into the slot. The stem marker should be inserted as far as possible into the spacing block and the femur and tibia marked.

8. The spacing block is removed and the knee flexed and the centers for the stems noted. If the marked centers do not appear centrally located on the cut ends of the bones, they should be shifted and re-marked at this point. The location for the stem on the femur should be as far posterior as possible consistent with keeping the stem in the medullary canal and allowing the patellar flange to end up flush with the anterior cortical surface of the femur. Medullary holes are then drilled at the sites selected perpendicular to the plane of the osteotomy cuts.

9. The stem of the femoral shaping jig is inserted into the femur and the jig should seat flush against the cut surface. Appropriate rotation about a longitudinal axis is judged visually and the posterior portions of the femoral condyles are removed by osteotomy as indicated by the jig. The jig is then removed.

10. The hole for the stem of the tibial plateau prosthesis is enlarged somewhat and slots made for the fins on the undersurface of the tibial plateau holder. This portion of the prosthesis is then seated in the tibia, driving it firmly into place with the prosthesis driver (Figure 4). The prosthesis can be driven into the tibial with the knee in acute flexion, although some difficulty may be encountered in getting the posterior edge of the tibial plateau prosthesis past the cut edge of the femur. Appropriate wedging with periosteal elevator and some attention to the degree of flexion will make this possible.

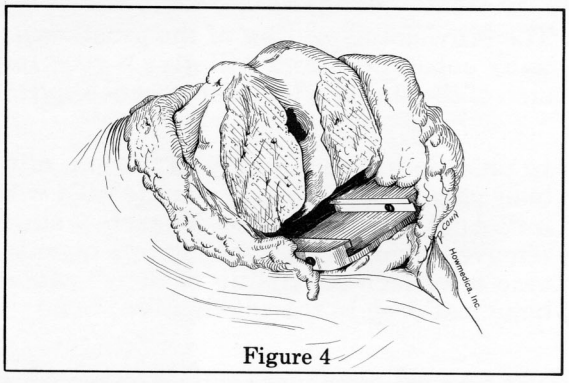


Figure 4

11. The plastic tibial plateau component is then seated in the plateau holder and the rotation guide is seated on the femur (Figure 5). The sphere on the distal end of the rotation guide is then articulated with the tibial plateau prosthesis and the knee joint extended.

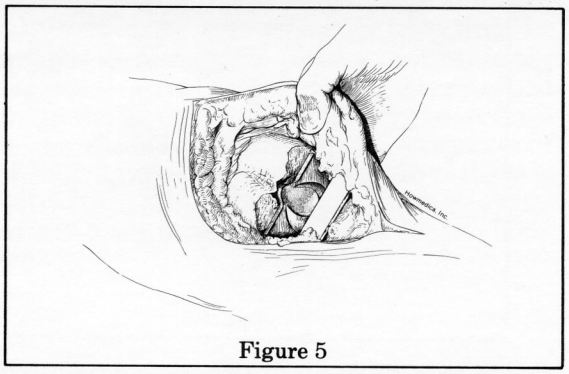


Figure 5

Once again, the joint should be relatively stable at this point in full extension. The joint is flexed and extended through a 30 degree arch from full extension, noting the posterior edge of the lateral extensions of the rotation guide. These edges should remain evenly separated from the tibial plateau component through this range of flexion. The rotation guide can be rotated on the long axis of the femur until appropriate alignment is obtained. At that point, the anterior edges of the lateral projections on the rotation guide are indicated on the distal cut end of the femur by scoring lightly with an osteotome. The rotation guide is then removed.

12. The femoral shaping jig is then re-inserted into the femur and the anterior portions of the lateral extensions are aligned with the previously scored marks from the rotation guide. The most anterior flat surface of the jig is used as a guide to remove the most anterior surface of the femur—the femoral patellar articulation—which should come off approximately smooth with the femoral shaft. The lateral extension which are beveled are then used to bevel the anterior portion of the femur and the posterior portion is inspected to revise the cuts to the posterior femoral condyles if revision is needed. The jig is then removed and the beveling is completed across the anterior femur. The hole for the femoral stem is enlarged by ronguering cortical bone most frequently present in the posterior portion of the hole for the femoral prosthetic stem, and the femoral prosthesis is seated (Figure 6). At this point, the knee joint should articulate satisfactorily and flex to a range of 90 to 100 degrees from full extension without subluxation or dislocation. If the motion is not smooth, then one must inspect to insure that the posterior cruciate has been totally removed.

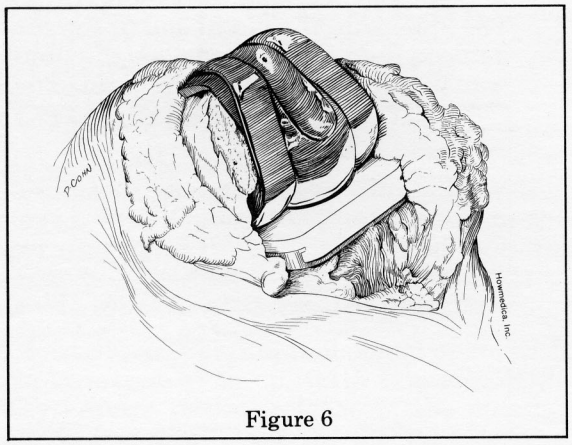


Figure 6

13. At this point all prosthetic components are removed and the joint surfaces irrigated. Removal of the tibial plateau holder is once again potentially difficult but with the knee in flexion, a periosteal elevator behind the posterior edge of the tibial plateau, wedging against the femur will allow it to be slipped by the posterior edge of the femur as it is driven out. Methyl methacrylate cement is then utilized to seat first the tibial plateau holder, and second the femoral prosthetic component. Care must be taken to insure that there is no cement in the holes for the locking pin or in the groove for the plastic tibial plateau insert. During the setting of the femoral component, the joint may be articulated and brought into full extension to insure adequate seating of the femoral component.

14. After removal of excess cement, the locking pin is screwed across the tibial plateau holder, locking the tibial plateau in place. If the joint is excessively lax at this point, the thick tibial plateau may be utilized in place of the standard tibial plateau. Correction for varus or valgus may be accomplished with the use of the right or left elevated tibial plateau. Flexion with the patella in place may indicate that the distal pole of the patella impinges on the sphere in 90 degrees of flexion. A portion of the undersurface of the distal pole of the patella may be removed at this point to facilitate flexion.

15. A suction drain tube is placed in the knee joint and the wound closed in appropriate layers with particular attention to the inferior medial closure of the extensor retinaculum. A bulky compression dressing consisting of Kerlix, cotton, and basswood splints medially, laterally, and posteriorly, and bias cut stockinette is applied. The tourniquet may be released before closure if desired.

Post-operative Routine

The leg is elevated for two or three days to minimize swelling. The suction drain is removed at 24 to 48 hours, depending upon the amount of drainage. Patients are started on protected ambulation after the third or fourth day with the bulky dressing in place. They are encouraged to walk with as much weight bearing as tolerated on the involved leg.

The dressing is removed at ten days and gentle flexion, active and passive, is begun. At this point, weight bearing is once again allowed up to tolerance according to the patient. If flexion to 70 degrees has not been obtained within two weeks of the time of the operation, a manipulation under anesthesia is performed.

Special Considerations

The procedure for insertion of this prosthesis allows adjustments to be made at several stages. The initial seating of the spacing block is the best indicator of the end result at the completion of the procedure; and if the knee is not stable with the spacing block in place, or not aligned satisfactorily, steps should be taken at this point to correct the problem. If the knee is unstable with the spacing block in place after the initial cuts are made, one can plan either to seat the prosthetic components with additional glue underneath them to take up space or utilize a thicker tibial plateau insert.

The provisional seating of the prosthesis is usually substantial and will give a good impression of the status after final cement application.

In order to insure stability in flexion, minimal bone should be removed from the tibia with the initial cut. The tibial articular surface should be removed along with subchondral bone to provide a surface consisting of dense cancellous bone just deep to the subchondral bone.

The femoral component should be seated on the distal femur so that the patellar flange is smooth against the anterior cortical surface of the femur.

If this is accomplished, then the prosthesis will be far enough posterior to once again insure stability of the knee in flexion and also will insure that the prosthesis is in satisfactory alignment to allow full extension.

The locking screw for the tibial insert can only be inserted from left to right. This may create some difficulty when performing the arthroplasty on the left knee through a median parapatellar incision. If the skin and deeper tissues cannot be retracted sufficiently to allow insertion of the locking pin, a smooth Steinman pin can be inserted from right to left through the hole and out through the skin so that the pin can be inserted through a small nick in the skin laterally. Difficulty encountered in inserting the pin will be due either to failure to completely seat the tibial articular component or to retained cement in the threads for the locking pin. A final inspection should be made prior to insertion of the tibial articular surface to insure that there is no obstructing cement either on the metal tray for the articular insert or the holes for the locking pin.

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